Stratospheric Analyses in MERRA
&
Atmospheric Constituent Capabilities

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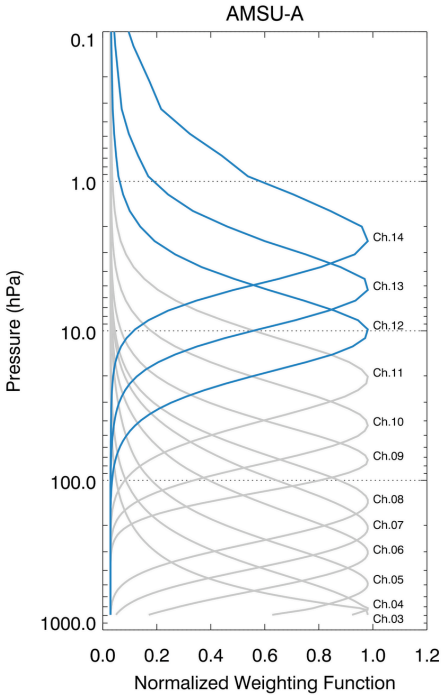
Themes

- The stratosphere in GEOS-5/MERRA analyses
- Chemistry simulations using MERRA analyses:
  - On-line (i.e., chemistry modules in GEOS-5)
  - Off-line (i.e., MERRA analyses driving CTMs)

The Stratosphere in GEOS-5/MERRA

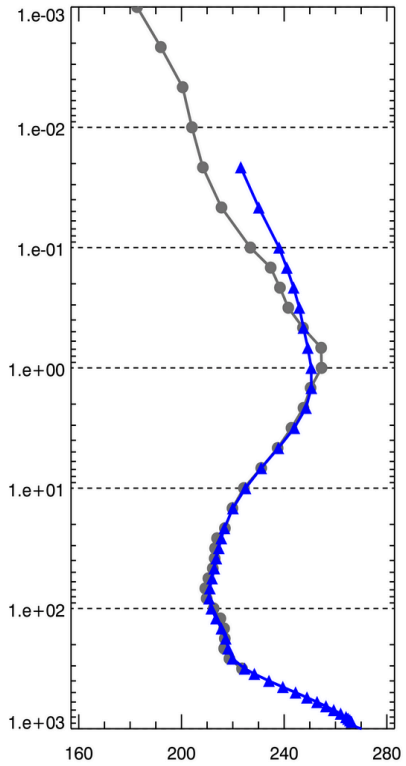
- GEOS-5 GCM extends to 0.01hPa (~80km)
- Temperature constraints to 0.4hPa (~55km):
  - Sonde measurements to about 10hPa
  - "Dense" satellite radiances in lower stratosphere
  - SSU Channels 1-3 (1979 onwards, to 2006)
  - AMSU-A Channels 12, 13, 14 (after 1997)
- V8 SBUV retrievals constrain ozone
  - Total columns
  - Partial profiles for p<64hPa (~20km)
- No suitable stratospheric moisture data
- Other trace gases not assimilated



AMSU-A Weighting Functions

Temperature Validation

Good performance in the stratosphere; some uncertainty near the stratopause



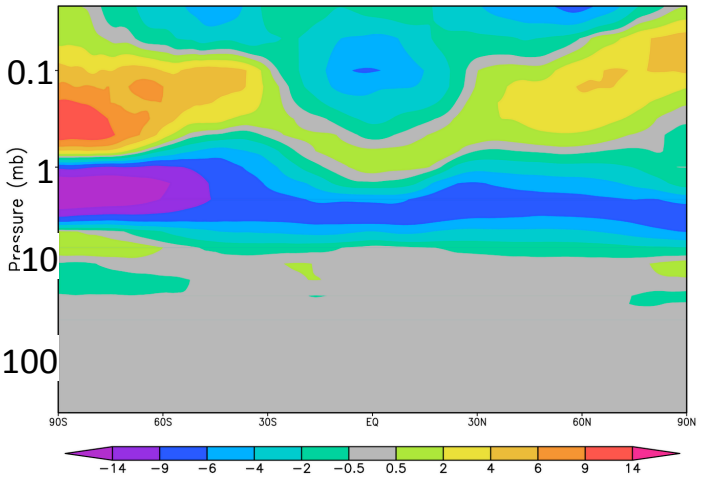
MLS (black) and GEOS-5.2.0 (blue) Temperatures in February 2008 – Northern middle latitudes

- Validation is performed against various independent datasets
- This comparison is with NASA's Microwave Limb Sounder (MLS) retrievals for February 2008
- Similar results are evident with sparse lidar data (e.g., Table Mountain, Mauna Loa) and other satellite instruments

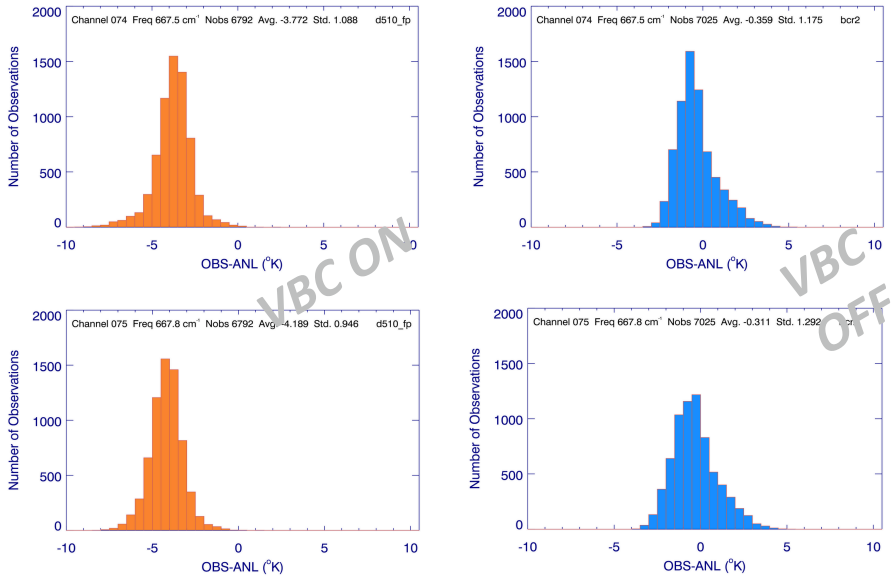
Emily Liu, Nicole McKee

Use of AMSU-A Channel 14

Variational bias correction (VBC) is not applied to AMSU-A Channel 14 radiances



Temperature differences with bias correction on or off on August 15, 2008. Values reach ±14K.



PDFs of O-F T_B (K) for two high-peaking AIRS channels: model bias propagates into the analyses when AMSU-A Ch. 14 VBC is turned on (left) and there is better agreement without VBC (right). These AIRS channels are not assimilated.

Emily Liu

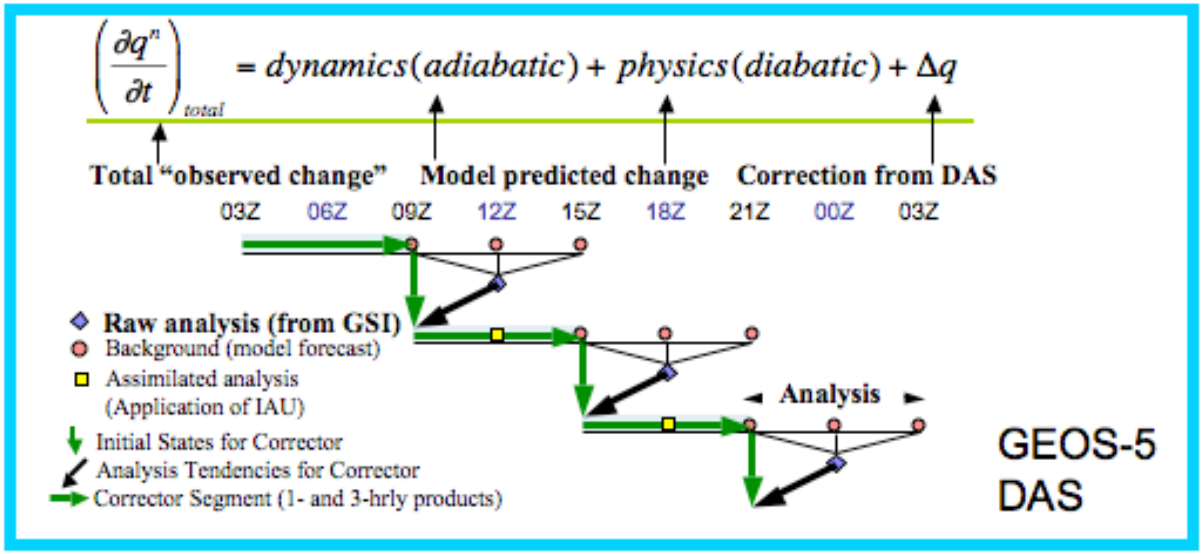
Transport – CTM Products

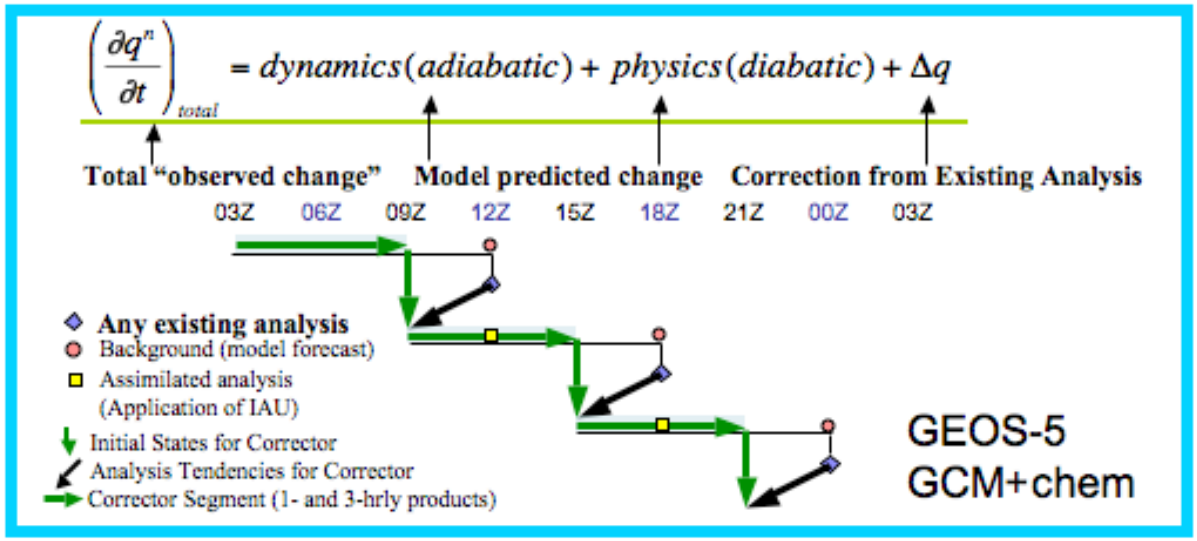
- Chemistry-transport models driven by:
  - Analyzed winds, temperature, etc.
  - Sub-grid quantities, such as cloud mass fluxes
- Products are archived as “chem” stream
  - Resolution reduced to 1°×1.25°L72
  - Mass fluxes as well as winds
  - Will provide GEOS-5-compatible transport core
- Downsides: impact of averaging and I-O cost

On-Line Constituents

- Cost-effective and more accurate than CTM
- Uses constituent packages built into GEOS-5:
  - Stratospheric Ozone Chemistry
  - GOCART Aerosol
  - GMI COMBO
  - Carbon species
  - Idealized trace gases (e.g., ^{222}Rn, age of air, …)
- So-called “replay” mode reproduces time series of analyses with accurate (time resolved) transport and less I-O than CTM

Schematic of “replay”

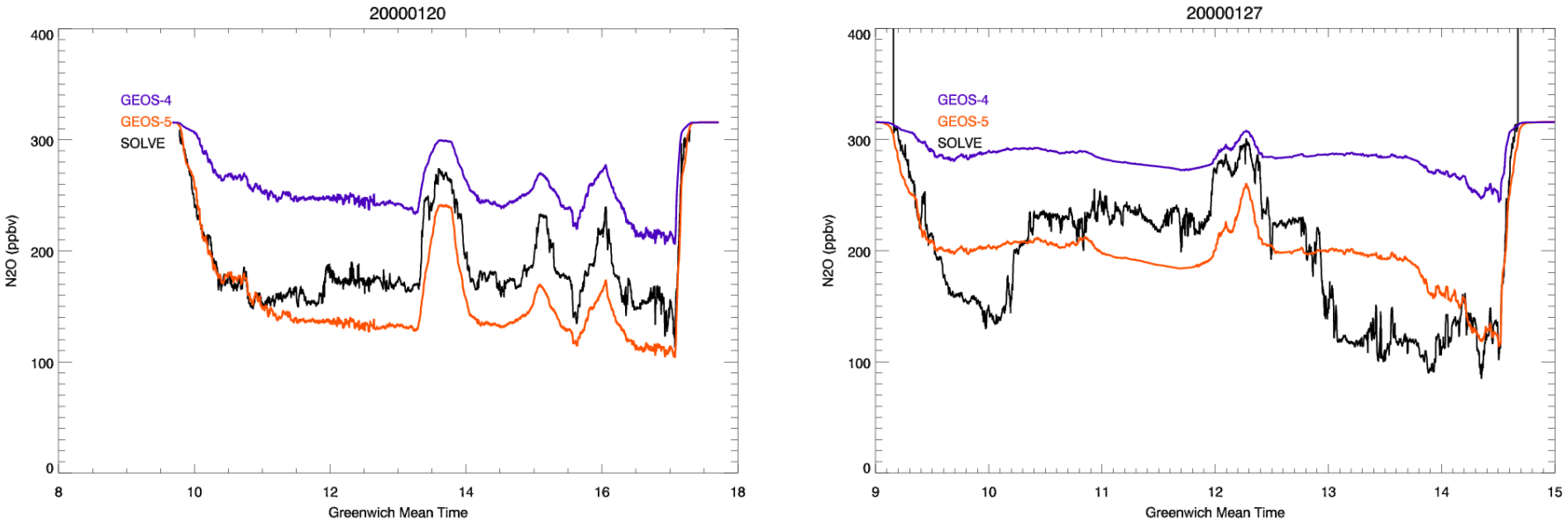




Max Suarez

N_2O simulations with GEOS-5.2.0

Stratospheric transport appears well represented in the MERRA analysis system

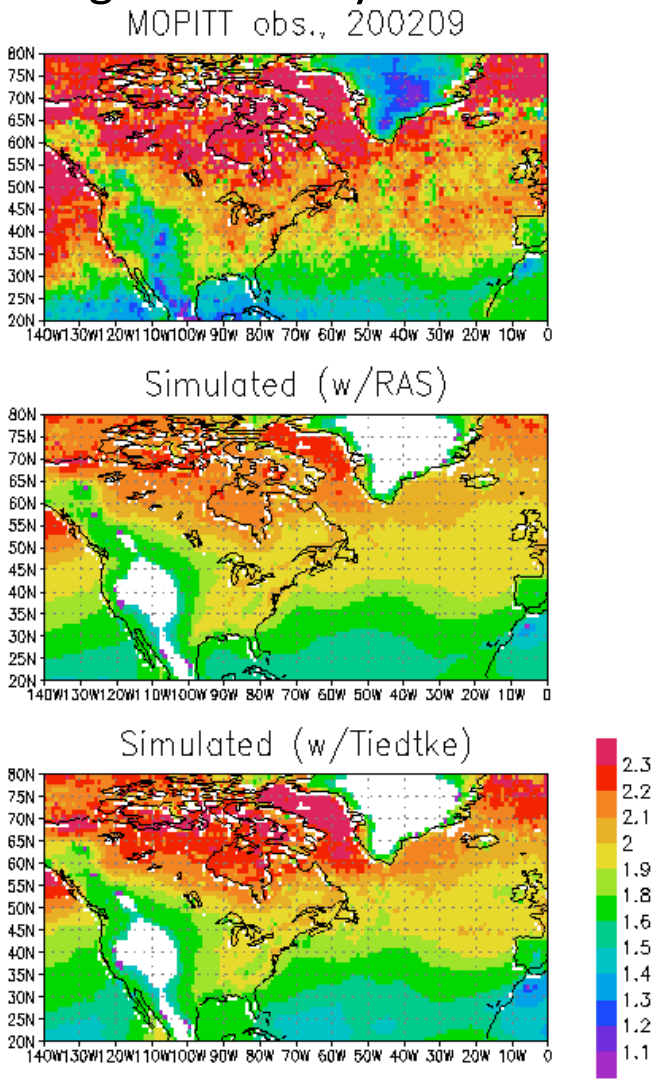


- Simulations use meteorology from 2°×2.5°L72 MERRA "SCOUT" runs
- Stratospheric chemistry package (Code 613.3) turned on for "replay"
- Comparison here is with in-situ data from SOLVE ER-2 flights on Jan 20 and Jan 27, 2000
- GEOS-5 (red) in much better agreement with SOLVE N_2O data than is GEOS-4 (blue)
- GEOS-5 somewhat better at resolving individual peaks (better spatial gradients)
- Will be re-done using MERRA runs

Craig Benson

CO simulations using GEOS-5.2.0

Examining uncertainty due to “true” and “approximate” sub-grid cloud transport



Zhengxin Zhu

- GEOS-5 meteorology from 2°×2.5°L72 MERRA “SCOUT” runs
- CO module implemented using prescribed sources and linearized loss
- Plots show MOPITT observations and two simulations over N. America/ Atlantic for September 2002
- First simulation (middle) uses the “true” convective transport (RAS) from GEOS-5.
- Second simulation (bottom) uses same cloud mass fluxes but a different (diffusive) numerical algorithm.
- Interestingly, CO columns values are closer to MOPITT when “diffusive” transport algorithm is used

Summary

- Have given a “sample” of the work being done
- Stratosphere in MERRA has some integrity – some uncertainty near the stratopause
- Don’t trust the mesosphere – we did not try to analyze it!
- Stratospheric transport shows promise
- Transport by sub-grid processes in the troposphere remains a very interesting research question!